EXPRESS MAIL NO. EV335607196US

SPECIFICATION

TITLE OF THE INVENTION

OPTICAL RECORDING MEDIUM

BACKGROUND OF THE INVENTION

The present invention relates to an optical recording medium and, particularly, to a data rewritable type optical recording medium whose characteristics of recording data therein at a high linear velocity can be improved and whose data reproduction durability and storage reliability can be simultaneously improved.

DESCRIPTION OF THE PRIOR ART

Optical recording media such as the CD, DVD and the like have been widely used as recording media for recording digital data. These optical recording media can be roughly classified into optical recording media such as the CD-ROM and the DVD-ROM that do not enable writing and rewriting of data (ROM type optical recording media), optical recording media such as the CD-R and DVD-R that enable writing but not rewriting of data (write-once type optical recording media), and optical recording media such as the CD-RW and DVD-RW that enable rewriting of data (data rewritable type optical recording media).

As well known in the art, data are generally recorded in a ROM type optical recording medium using prepits formed in a substrate in the manufacturing process thereof, while in a write-once type optical recording medium, an organic dye such as a cyanine dye, phthalocyanine dye or azo dye is generally used as the material of the recording layer and data are recorded utilizing changes in an optical characteristic caused by chemical change of the organic dye, which change may be accompanied by physical deformation.

On the other hand, in a data rewritable type optical recording medium, a phase change material is generally used as the material of the recording layer and data are recorded utilizing changes in an optical

characteristic caused by phase change of the phase change material. More specifically, since the reflection coefficients of the phase change material are different between the case where the phase change material is in a crystal phase and the case where it is in an amorphous phase, data can be recorded and reproduced utilizing these characteristics of the phase change material.

In the case where data are to be recorded in a recording layer of a data rewritable type optical recording medium, a laser beam whose power is set to a recording power *Pw* having a sufficiently high level is projected onto the recording layer to heat a region of the recording layer irradiated with the laser beam to a temperature equal to or higher than the melting point of a phase change material, thereby melting the region of the recording layer. Then, a laser beam whose power is set to a bottom power *Pb* having a sufficiently low level is projected onto the recording layer to quickly cool the melted region of the recording layer. As a result, the phase of the phase change material contained in the region of the recording layer changes from a crystal phase to an amorphous phase to form a record mark, thereby recording data therein.

On the other hand, in the case where a record mark formed in the recording layer of a data rewritable type optical recording medium is to be erased, a laser beam whose power set to the erasing power *Pe* having a level lower than the recording power *Pw* and equal to or higher than the bottom power *Pb* is projected onto the recording layer to heat a region of the recording layer where a record mark is formed to a temperature equal to or higher than the crystallization temperature of the phase change material and the region of the recording layer heated to the temperature equal to or higher than the crystallization temperature of the phase change material is gradually cooled. Thus, the phase of the phase change

material contained at the region of the recording layer where the record mark was formed changes from an amorphous phase to a crystalline phase and the record mark is erased.

Therefore, it is possible not only to form a record mark in the recording layer but also to directly overwrite a record mark formed in the region of the recording layer by modulating the power of the laser beam projected onto the recording layer between a plurality of levels corresponding to the recording power *Pw*, the bottom power *Pb* and the erasing power *Pe*.

A chalcogen system alloy such as a GeSbTe system alloy, an AgInSbTe alloy or the like is known as a phase change material usable for a recording layer of a data writable type optical recording medium.

A chalcogen system alloy containing Sb and Te has a high crystallization speed and is suitable as a phase change material for a recording layer of a data writable type optical recording medium in which data are recorded at a high speed. Of particular interest is that the crystallization speed of a chalcogen system alloy increases as the ratio of Sb to Te contained in the alloy increases. An optical recording medium whose recording layer contains such an alloy therefore enables recorded data to be directly overwritten at a high linear velocity.

However, as the ratio of Sb to Te contained in a chalcogen system alloy increases, the crystallization temperature of the chalcogen system alloy decreases while the crystallization speed of the chalcogen system alloy increases and, therefore, the thermal stability thereof in an amorphous phase becomes lower. Specifically, in the case where the crystallization temperature of a chalcogen system alloy contained in a recording layer of an optical recording medium is low, the storage reliability of the optical recording medium may be degraded because there

is a risk of record marks being erased when data are repeatedly reproduced from the optical recording medium or the optical recording medium is stored in a high-temperature atmosphere.

SUMMARY OF THE INVENTION

It is therefore an object of the present invention to provide a data rewritable type optical recording medium that has improved high-linear-velocity data recording characteristics and is simultaneously improved in data reproduction durability and storage reliability.

The above and other objects of the present invention can be accomplished by an optical recording medium comprising a recording layer in which a record mark can be formed by projecting a laser beam thereonto, a first dielectric layer disposed on the side of the recording layer on which a light incidence plane through which the laser beam enters is present, a second dielectric layer disposed on the side of the recording layer opposite from that on which the light incidence plane is present, a heat radiation layer disposed on the side of the first dielectric layer on which the light incidence plane is present and a reflective layer disposed on the side of the second dielectric layer opposite from that on which the light incidence plane is present, the recording layer containing a phase change material represented by an atomic composition formula: $Sb_aTe_bGe_cMn_d$, where *a* is equal to or larger than 55 and equal to or smaller than 70, *c* is equal to or larger than 4 and equal to or smaller than 10, *d* is equal to or larger than 10 and equal to or smaller than 20, *a*/*b* is equal to or larger than 2.8 and equal to or smaller than 3.5 and *a*/*d* is equal to or larger than 3.0 and equal to or smaller than 6.0, in an amount equal to or more than 95 atomic %.

In a study done by the inventors of the present invention, it was

found that the phase change material represented by the above atomic composition formula: $Sb_aTe_bGe_cMn_d$ had an extremely high crystallization speed and, therefore, in the case where an optical recording medium included a recording layer containing the phase change material in an amount equal to or more than 95 atomic %, data recorded in the recording layer of the optical recording medium could be overwritten at an extremely high linear velocity, for example, a linear velocity equal to or higher than 5m/sec and lower than 14 m/sec.

In a further study done by the inventors of the present invention, it was found that since the phase change material had a relatively high crystallization temperature and the thermal stability thereof in an amorphous phase was high, namely, the crystallization temperature was equal to or higher than 220 °C and the activation energy was equal to or higher than 3.0 eV, an optical recording medium that included a recording layer containing the phase change material in an amount equal to or more than 95 atomic % was improved in data reproduction durability and storage reliability.

Therefore, according to the present invention, it is possible to directly overwrite data recorded in a recording layer of an optical recording medium and it is possible to simultaneously improve the data reproduction durability and the storage reliability of the optical recording medium.

In the present invention, in order to control the crystallization temperature of the phase change material, the recording layer may contain elements such as In other than Sb, Te, Ge and Mn, such as In or the like, in an amount equal to or less than 5 atomic % and may further contain unavoidable impurities.

In a further study done by the inventors of the present invention,

it was found that the crystallization velocity and the crystallization temperature of the phase change material increased as the Mn content of the phase change material increased, but that if the crystallization velocity and the crystallization temperature of the phase change material were too high, it was difficult in the case of recording data at a low linear velocity to form a record mark by changing the phase of the phase change material from the crystalline phase to the amorphous phase.

Therefore, in the present invention, it is preferable for the phase change material represented by the above atomic composition formula: $Sb_aTe_bGe_cMn_d$ and contained in the recording layer in an amount equal to or more than 95 atomic % to have such a composition that *a* is equal to or larger than 55 and equal to or smaller than 62, *c* is equal to or larger than 4 and equal to or smaller than 10, *d* is equal to or larger than 13 and equal to or smaller than 18, *a*/*b* is equal to or larger than 2.9 and equal to or smaller than 3.2 and *a*/*d* is equal to or larger than 3.0 and equal to or smaller than 4.0.

In a preferred aspect of the present invention, the heat radiation layer contains aluminum nitride as a primary component.

According to this preferred aspect of the present invention, since the heat radiation layer disposed on the side of the first dielectric layer on which the light incidence plane is present contains aluminum nitride as a primary component, the heat radiation characteristics of the recording layer can be increased and it is therefore possible to improve the durability of the optical recording medium when data are reproduced repeatedly.

Furthermore, according to this preferred aspect of the present invention, since the heat radiation layer is disposed on the side of the recording layer on which the light incidence plane is present, it is possible

to prevent the heat radiation characteristics of the recording layer from increasing too much and it is therefore possible to effectively prevent the recording sensitivity of the optical recording medium from being lowered.

In the present invention it is preferable to form the heat radiation layer of a material containing 90 atomic % or more aluminum nitride and is more preferable to form it of a material containing 95 atomic % or more aluminum nitride.

In the present invention, it is preferable to form the heat radiation layer so as to have a thickness of 50 nm to 150 nm and is more preferable to form it so as to have a thickness of 80 nm to 120 nm.

In a preferred aspect of the present invention, the reflective layer contains Ag or alloy containing 90 atomic % or more of Ag.

According to this preferred aspect of the present invention, since the reflective layer disposed on the side of the second dielectric layer opposite from that on which the light incidence plane is present contains Ag or alloy containing 90 atomic % or more of Ag, the heat radiation characteristics of the recording layer can be increased and it is therefore possible to improve the durability of the optical recording medium when data are reproduced repeatedly.

In the present invention, each of the first dielectric layer and the second dielectric layer is preferably formed of a mixture of ZnS and SiO_2.

In the present invention, the first dielectric layer is preferably formed so as to have a thickness of 10 nm to 40 nm and the second dielectric layer is preferably formed so as to have a thickness of 3 nm to 16 nm.

In a preferred aspect of the present invention, the phase change material represented by the atomic composition formula: $Sb_aTe_bGe_cMn_d$ and contained in the recording layer has such a composition that *a* is

equal to or larger than 55 and equal to or smaller than 70, *c* is equal to or larger than 4 and equal to or smaller than 10, *d* is equal to or larger than 10 and equal to or smaller than 20, *a/b* is equal to or larger than 2.8 and equal to or smaller than 3.5 and *a/d* is equal to or larger than 3.0 and equal to or smaller than 6.0, and a linear recording velocity equal to or higher than 5 m/sec and lower than 14 m/sec is written in the optical recording medium as data for setting recording conditions indicating a preferable linear recording velocity of data.

In a further preferred embodiment of the present invention, data for setting recording conditions indicating that a ratio *Pe/Pw* of an erasing power of a laser beam *Pe* to a recording power *Pw* thereof should be determined to be equal to or larger than 0.3 and equal to or smaller than 0.7 are further written in the optical recording medium.

In another preferred aspect of the present invention, ID data for identifying the optical recording medium are written in the optical recording medium.

The above and other objects and features of the present invention will become apparent from the following description made with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a schematic perspective view showing an optical recording medium that is a preferred embodiment of the present invention.

Figure 2 is an enlarged schematic cross-sectional view of the part of the optical recording medium indicated by A in Figure 1.

Figure 3 is a diagram showing the waveform of a pulse train pattern for modulating the power of a laser beam in the case of recording

a 2T signal in a recording layer of an optical recording medium shown in Figures 1 and 2.

Figure 4 is a diagram showing the waveform of a pulse train pattern for modulating the power of a laser beam in the case of recording a 3T signal in a recording layer of an optical recording medium shown in Figures 1 and 2.

Figure 5 is a diagram showing the waveform of a pulse train pattern for modulating the power of a laser beam in the case of recording a 4T signal in a recording layer of an optical recording medium shown in Figures 1 and 2.

Figure 6 is a diagram showing the waveform of a pulse pattern for modulating the power of a laser beam in the case of recording one among a 5T signal to a 8T signal in a recording layer of an optical recording medium shown in Figures 1 and 2.

Figure 7 is a diagram showing a data recording apparatus for recording data in the optical recording medium 10.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Figure 1 is a schematic perspective view showing an optical recording medium that is a preferred embodiment of the present invention and Figure 2 is a schematic enlarged cross-sectional view indicated by A in Figure 1.

As shown in Figure 1, an optical recording medium 10 according to this embodiment is formed disk-like and has an outer diameter of about 120 mm and a thickness of about 1.2 mm.

As shown in Figure 2, the optical recording medium 10 according to this embodiment includes a disk-like support substrate 11, a reflective layer 12, a second dielectric layer 13, a recording layer 14, a first

dielectric layer 15, a heat radiation layer 16 and a light transmission layer 17.

The optical recording medium 10 according to this embodiment is constituted so that a laser beam L having a wavelength λ of 380 nm to 450 nm is projected onto the recording layer 14 via the light transmission layer 17 and a light incidence plane 17a is formed by the surface of the light transmission layer 17.

The support substrate 11 serves as a support for ensuring mechanical strength and a thickness of about 1.2 mm required for the optical recording medium 10.

The material used to form the support substrate 11 is not particularly limited insofar as the support substrate 11 can serve as the support of the optical recording medium 10. The support substrate 11 can be formed of glass, ceramic, resin or the like. Among these, resin is preferably used for forming the support substrate 11 since resin can be easily shaped. Illustrative examples of resins suitable for forming the support substrate 11 include polycarbonate resin, polyolefin resin, acrylic resin, epoxy resin, polystyrene resin, polyethylene resin, polypropylene resin, silicone resin, fluoropolymers, acrylonitrile butadiene styrene resin, urethane resin and the like. Among these, polycarbonate resin and polyolefin resin are most preferably used for forming the support substrate 11 from the viewpoint of easy processing, optical characteristics and the like and in this embodiment, the support substrate 11 is formed of polycarbonate resin. In this embodiment, since the laser beam L is projected onto the recording layer 14via the light transmission layer 17 located opposite to the support substrate 11, it is unnecessary for the support substrate 11 to have a light transmittance property.

In this embodiment, the support substrate 11 has a thickness of

about 1.1 mm.

As shown in Figure 2, grooves 11a and lands 11b are alternately and spirally formed on the surface of the support substrate 11. The grooves 11a and/or lands 11b serve as a guide track for the laser beam L when data are to be recorded in the optical recording medium 10 or when data are to be reproduced from the optical recording medium 10.

The depth of the groove 11a is not particularly limited and is preferably set to 10 nm to 40 nm. The pitch of the grooves 11a is not particularly limited and is preferably set to 0.2 μm to 0.4 μm.

It is preferable to fabricate the support substrate 11 by an injection molding process using a stamper but the support substrate 11 may be fabricated using another process such as a 2P process.

The reflective layer 12 serves to reflect the laser beam L entering through the light incidence plane 17a so as to emit it from the light incidence plane 17a and effectively radiate heat generated in the recording layer 14 by the irradiation with the laser beam L. Further, the reflective layer 12 serves to increase a reproduced signal (C/N ratio) by a multiple interference effect.

In this embodiment, the reflective layer 12 is formed of Ag or alloy containing 95 atomic % or more of Ag, thereby improving the reflection coefficient thereof and a property thereof for radiating heat generated in the recording layer 14.

It is preferable to form the reflective layer 12 to have a thickness of 20 to 200 nm and is more preferable to form it to have a thickness of 7 to 150 nm.

In the case where the thickness of the reflective layer 12 is thinner than 20 nm, the above described effects cannot sufficiently be obtained. On the other hand, in the case where the thickness of the reflective layer

12 exceeds 200 nm, the surface smoothness of the reflective layer 12 is degraded and it takes a longer time for forming the reflective layer 12, thereby lowering the productivity of the optical recording medium 10.

The recording layer 14 is a layer in which record marks are to be formed, whereby data are recorded. The recording layer 14 is formed of a phase change material.

The reflection coefficients of the phase change material are different between the case where the phase change material is in a crystal phase and the case where it is in an amorphous phase, and data are recorded utilizing this characteristic of the phase change material.

When the laser beam L is projected onto the recording layer 14, whereby the phase of a region of the recording layer 14 is changed from a crystal phase to an amorphous phase to form a record mark, the laser beam L set to the recording power *Pw* is projected onto the recording layer 14 via the light transmission layer 17 to heat the region of the recording layer 14 irradiated with the laser beam L to a temperature equal to or higher than the melting point of the phase change material, thereby melting it and the laser beam L set to the bottom power *Pb* lower than the recording power *Pw* is then projected onto the recording layer 14, thereby quickly cooling the melted region of the recording layer 14 to change the phase thereof to an amorphous phase. Thus, a record mark is formed at the region of the recording layer 14 whose phase is in an amorphous phase.

Data are constituted by the length of the record mark and the length of the blank region between the record mark and the neighboring record mark in the direction of the track.

The length of the record mark and that of the blank region are each determined to be an integral multiple of T, where T is a length

corresponding to one cycle of a reference clock and in the 1,7RLL Modulation Code, a record mark and a blank region having a length of 2T to 8T are used.

On the other hand, when the region of the recording layer 14 in an amorphous phase is crystallized, thereby erasing the record mark, the laser beam L set to the erasing power *Pe* equal to or higher than the bottom power *Pb* and lower than the recording power *Pw* is projected onto the recording layer 14 via the light transmission layer 17 to heat the region of the recording layer 14 to a temperature equal to or higher than the crystallization temperature of the phase change material and the region of the recording layer 14 is gradually cooled by moving the laser beam L away therefrom. Thus, the region of the recording layer 14 is crystallized and the record mark is erased.

Therefore, it is possible by modulating the power of the laser beam L projected onto the recording layer 14 to form a record mark in the recording layer 14 and directly overwrite a record mark formed in the region of the recording layer 14.

In this embodiment, the recording layer 14 contains a phase change material represented by an atomic composition formula: $Sb_aTe_bGe_cMn_d$ in an amount equal to or more than 95 atomic % where a is equal to or larger than 55 and equal to or smaller than 70, c is equal to or larger than 4 and equal to or smaller than 10, d is equal to or larger than 10 and equal to or smaller than 20, a/b is equal to or larger than 2.8 and equal to or smaller than 3.5 and a/d is equal to or larger than 3.0 and equal to or smaller than 6.0.

In a study done by the inventors of the present invention, it was found that the phase change material represented by the above atomic composition formula: $Sb_aTe_bGe_cMn_d$ had an extremely high crystallization

speed and, therefore, in the case where an optical recording medium 10 included a recording layer 14 containing the phase change material in an amount equal to or more than 95 atomic %, data recorded in the recording layer 14 of the optical recording medium 10 could be overwritten at an extremely high linear velocity, for example, a linear velocity equal to or higher than 5m.sec and lower than 14 m/sec.

In a further study done by the inventors of the present invention, it was found that since the phase change material had a relatively high crystallization temperature and the thermal stability thereof in an amorphous phase was high, namely, the crystallization temperature was equal to or higher than 220 °C and the activation energy was equal to or higher than 3.0 eV, an optical recording medium 10 that included a recording layer 14 containing the phase change material in an amount equal to or more than 95 atomic % was improved in data reproduction durability and storage reliability.

However, another study done by the inventors of the present invention showed that in the case where *a/d* in the above atomic composition formula: $Sb_aTe_bGe_cMn_d$ was larger than 6.0, it was impossible to improve data reproduction durability of an optical recording medium 10 because the phase change material did not have a sufficiently high crystallization temperature.

Further, in a further study done by the inventors of the present invention, it was found that in the case where *a/d* in the above atomic composition formula: $Sb_aTe_bGe_cMn_d$ was smaller than 3.0, the crystallization temperature of the phase change material became too high and when the linear recording velocity was equal to or higher than 5 m/sec and lower than 14 m/sec, it was difficult to change the phase of the phase change material from the crystalline phase to the amorphous phase

to form a record mark.

Moreover, in a study done by the inventors of the present invention, it was found that even in the case where *a/d* in the above atomic composition formula: $Sb_aTe_bGe_cMn_d$ was equal to or more than 3.0 and equal to or less than 6.0, in the case where *a* was smaller than 55, *c* was larger than 10, *d* was smaller than 10 or *a/b* was smaller than 2.8, the crystallization speed became too low and when the linear recording velocity of data was equal to or higher than 5 m/sec and lower than 14 m/sec, it was difficult to crystallize the phase change material to erase a record mark and that, on the other hand, in the case where *a* was larger than 70, *d* was larger than 20 or *a/b* was larger than 3.5, the crystallization speed became too high and when the linear recording velocity of data was equal to or higher than 5 m/sec and lower than 14 m/sec, it was difficult to change the phase of the phase change material from the crystalline phase to the amorphous phase to form a record mark. Further, the inventors of the present invention found that in the case where *c* was smaller than 4, since the content of Ge became too small, the crystallization speed became too low and the data reproduction durability and the storage reliability of the optical recording medium 10 were lowered.

In this embodiment, in order to control the crystallization temperature of the phase change material, the recording layer 14 may contain elements other than Sb, Te, Ge and Mn, such as In or the like, in an amount equal to or less than 5 atomic % and may further contain unavoidable impurities.

Since the recording sensitivity decreases as the recording layer 14 becomes thicker, it is preferable to form the recording layer 14 to be thin. However, when the recording layer 14 is too thin, the difference in the

optical constants between before and after data recording becomes small and a reproduced signal having a high level (C/N ratio) cannot be obtained. On the other hand, when the recording layer 14 is too thin, since the crystallization speed becomes markedly low, it is difficult to directly overwrite data and it is difficult to control the thickness of the recording layer 14 when it is formed. Therefore, the recording layer 14 is preferably formed to have a thickness of 2 to 40 nm, more preferably, to have a thickness of 4 to 30 nm and most preferably to have a thickness of 5 to 20 nm.

The heat radiation layer 16, the first dielectric layer 15 and the second dielectric layer 13 serve to physically and chemically protect the recording layer 14 and to increase the difference in the optical characteristics between before and after data recording. It is possible to effectively prevent data recorded in the recording layer 14 from being degraded for a long time by sandwiching the recording layer 14 by the first dielectric layer 15 and the second dielectric layer 13. In addition, the heat radiation layer 16 serves to quickly radiate heat generated in the recording layer 14.

The material usable for forming the second dielectric layer 13 is not particularly limited insofar as it is transparent with respect to the laser beam L and it is preferable to form the second dielectric layer 13 of a mixture of ZnS and SiO_2. The mole ratio of ZnS to SiO_2 is preferably 40:60 to 60:40 and the mole ratio of ZnS to SiO_2 is most preferably about 50:50, since the mixture of ZnS and SiO_2 whose mole ratio of ZnS to SiO_2 is about 50:50 is chemically stable and has an excellent property for protecting the recording layer 14 when the second dielectric layer 13 is formed thereof.

The thickness of the second dielectric layer 13 is not particularly limited but the second dielectric layer 13 is preferably formed to have a

thickness of 3 nm to 16 nm. In the case where the thickness of the second dielectric layer 13 is thinner than 3 nm, it becomes difficult to protect the recording layer 14 in a desired manner and, on the other hand, in the case where the thickness of the second dielectric layer 13 exceeds 16 nm, there is a risk of cracks being generated in the second dielectric layer 13 due to internal stress and the heat radiation effect thereof becomes low.

On the other hand, the material for forming the first dielectric layer 15 on side of the light incidence plane 17a with respect to the recording layer 14 is not particularly limited but the first dielectric layer 15 is preferably formed of a mixture of ZnS and SiO_2. The mole ratio of ZnS to SiO_2 is preferably 70:30 to 90:10 and most preferably about 80:20. It is possible by forming the first dielectric layer 15 of such a material to improve the characteristics for protecting the recording layer 14 and effectively prevent the recording layer 14 from being deformed by heat generated when data are recorded therein. The thus formed first dielectric layer 15 has an excellent optical characteristic with respect to the laser beam L having a wavelength included in a blue wavelength region.

The thickness of the first dielectric layer 15 is not particularly limited but the first dielectric layer 15 is preferably formed to have a thickness of 10 nm to 60 nm and more preferably formed to have a thickness of 10 nm to 40 nm. In the case where the thickness of the first dielectric layer 15 is thinner than 10 nm, it becomes difficult to protect the recording layer 14 in a desired manner and on the other hand, in the case where the thickness of the first dielectric layer 15 exceeds 60 nm, the heat radiation effect of the heat radiation layer 16 becomes low.

The material for forming the heat radiation layer 16 is not particularly limited but the heat radiation layer 16 is preferably formed of

the material containing 90 atomic % or more of aluminum nitride. Since aluminum nitride has high thermal conductivity, when the heat radiation layer 16 is formed of the material containing 90 atomic % or more of aluminum nitride, it is possible to effectively radiate heat generated in the recording layer 14. Since the thermal conductivity of the heat radiation layer 16 increases as the amount of aluminum nitride contained in the heat radiation layer 16 increases, it is more preferable for the heat radiation layer 16 to contain 95 atomic % or more of aluminum nitride.

The thickness of the heat radiation layer 16 is not particularly limited but it is preferable to form the heat radiation layer 16 to have a thickness of 50 nm to 150 nm and is more preferable to form the heat radiation layer 16 to have a thickness of 80 nm to 120 nm. In the case where the thickness of the heat radiation layer 16 is thinner than 50 nm, sufficient heat radiation characteristics cannot be obtained and, on the other hand, in the case where the thickness of the heat radiation layer 16 exceeds 150 nm, it takes much time to form the heat radiation layer 16, thereby lowering the productivity of the optical recording medium 10 and giving rise to a risk of cracks being generated in the heat radiation layer 16 due to internal stress.

In the case where the first dielectric layer 15 and the heat radiation layer 16 are integrated and formed of the material containing 90 atomic % or more of aluminum nitride, it is possible to much more effectively radiate heat generated in the recording layer 14. However, in the case where a layer integrated by the first dielectric layer 15 and the heat radiation layer 16 is formed of the material containing 90 atomic % or more of aluminum nitride, since the adhesiveness between itself and the recording layer 14 is low, the data overwriting characteristics are lowered if the layer is brought into direct contact with the recording layer

14, and since aluminum nitride has little enhancement effect, sufficient modulation cannot be obtained, whereby the jitter characteristics are lowered. Therefore, in this embodiment, the first dielectric layer 15 and the heat radiation layer 16 are separately provided.

Each of the reflective layer 12, the second dielectric layer 13, the recording layer 14, the first dielectric layer 15 and the heat radiation layer 16 can be formed using a gas phase growth process using chemical species containing elements for forming it. As the gas phase growth process, a sputtering process is preferably used.

The light transmission layer 17 serves to transmit the laser beam L and the light incidence plane 17a is constituted by the surface thereof.

It is preferable to form the light transmission layer 17 to have a thickness of 10 µm to 300 µm and is more preferable to form the light transmission layer 17 to have a thickness of 50 µm to 150 µm.

The material usable for forming the light transmission layer 17 is not particularly limited insofar as it has a sufficiently high light transmittance with respect to the laser beam L but it is preferable to form the light transmission layer 17 by applying acrylic ultraviolet ray curable resin or epoxy ultraviolet ray curable resin onto the surface of the heat radiation layer 16 using a spin coating process.

The light transmission layer 17 may be formed by adhering a sheet made of light transmittable resin to the surface of the heat radiation layer 16 using an adhesive agent.

When data are to be recorded in the thus constituted optical recording medium 10, a laser beam L whose power is set to the recording power *Pw* is projected onto the recording layer 14 via the light transmission layer 17 to heat a region of the recording layer 14 irradiated with the laser beam L to a temperature equal to or higher than the

melting point of the phase change material, thereby melting it.

The laser beam L whose power is set to the bottom power *Pb* lower than the recording power *Pw* is then projected onto the recording layer 14, thereby quickly cooling the melted region of the recording layer 14 to change the phase thereof to an amorphous phase.

Thus, a record mark is formed in the recording layer 14 and data are recorded therein.

Since the reflection coefficients of the phase change material are different between the case where the phase change material is in a crystal phase and the case where it is in an amorphous phase, data can be reproduced utilizing these characteristics of the phase change material.

On the other hand, when a record mark formed in the recording layer 14 is to be erased, the laser beam L whose power is set to the erasing power *Pe* equal to or higher than the bottom power *Pb* is projected onto a region of the recording layer 14 where the record mark is formed via the light transmission layer 17 to heat the region of the recording layer 14 irradiated with the laser beam L to a temperature equal to or higher than the crystallization temperature of the phase change material

Then, the region of the recording layer 14 is gradually cooled by moving the laser beam L away therefrom.

Thus, the phase change material contained is crystallized and the record mark which was formed at the region of the recording layer 14 is erased.

Each of Figures 3 to 6 is a diagram showing the waveform of a pulse train pattern for modulating the power of the laser beam L in the case of recording data in the recording layer 14 of the thus constituted optical recording medium 10, where Figure 3 shows a pulse train pattern used in the case of recording a 2T signal, Figure 4 shows a pulse train

pattern used in the case of recording a 3T signal, Figure 5 shows a pulse train pattern used in the case of recording a 4T signal and Figure 6 shows a pulse train pattern used in the case of recording one among a 5T signal to a 8T signal.

As shown in Figures 3 to 6, the power of the laser beam L is modulated between three levels, a recording power *Pw*, an erasing power *Pe* and a bottom power *Pb* where $Pw > Pe > Pb$.

The recording power *Pw* is set to such a high level that the phase change material contained in the recording layer 14 is heated to a temperature higher than the melting point thereof when the laser beam L whose power is set to the recording power *Pw* is projected onto the recording layer 14 and on the other hand, the erasing power *Pe* is set to such a level that the phase change material contained in the recording layer 14 is heated to a temperature equal to or higher than the crystallization temperature thereof when the laser beam L whose power is set to the recording power *Pe* is projected onto the recording layer 14. To the contrary, the bottom power *Pb* is set to such a low level that regions of the recording layer 14 heated by irradiation with the laser beam L whose power is set to the recording power *Pw* can be cooled by irradiation with the laser beam L whose power is set to the bottom power *Pb*.

Since the ratio *Pe/Pw* of the erasing power *Pe* to the recording power *Pw* greatly influences the data direct overwriting characteristics of the optical recording medium 10, it is preferable to determine it depending upon the linear recording velocity of data and in this embodiment, the ratio *Pe/Pw* is set to be equal to or larger than 0.3 and equal to or smaller than 0.7.

As shown in Figure 3, in the case of recording a 2T signal in the recording layer 14 of the optical recording medium 10, the power of the

laser beam L is modulated so that it is increased from the erasing power *Pe* to the recording power *Pw*, decreased from the recording power *Pw* to the bottom power *Pb* after passage of a predetermined time period t_{top}, and increased from the bottom power *Pb* to the erasing power *Pe* after passage of a predetermined time period t_{cl}.

Therefore, in the case of recording a 2T signal in the recording layer 14 of the optical recording medium 10, the number of pulses having a level equal to the recording power *Pw*, namely, the recording pulse number is set to be 1.

On the other hand, as shown in Figure 4, in the case of recording a 3T signal in the recording layer 14 of the optical recording medium 10, the power of the laser beam L is modulated so that it is increased from the erasing power *Pe* to the recording power *Pw*, decreased from the recording power *Pw* to the bottom power *Pb* after passage of a predetermined time period t_{top}, increased from the bottom power *Pb* to the recording power *Pw* after passage of a predetermined time period t_{off}, decreased from the recording power *Pw* to the bottom power *Pb* after passage of a predetermined time period t_{lp}, and increased from the bottom power *Pb* to the erasing power *Pe* after passage of a predetermined time period t_{cl}.

Therefore, in the case of recording a 3T signal in the recording layer 14 of the optical recording medium 10, the number of pulses having a level equal to the recording power *Pw*, namely, the recording pulse number is set to be 2.

Further, as shown in Figure 5, in the case of recording a 4T signal in the recording layer 14 of the optical recording medium 10, the power of the laser beam L is modulated so that it is increased from the erasing power *Pe* to the recording power *Pw*, decreased from the recording power *Pw* to the bottom power *Pb* after passage of a predetermined time period

t_{top}, increased from the bottom power *Pb* to the recording power *Pw* after passage of a predetermined time period t_{off}, decreased from the recording power *Pw* to the bottom power *Pb* after passage of a predetermined time period t_{mp}, increased from the bottom power *Pb* to the recording power *Pw* after passage of a predetermined time period t_{off}, decreased from the recording power *Pw* to the bottom power *Pb* after passage of a predetermined time period t_{lp}, and increased from the bottom power *Pb* to the erasing power *Pe* after passage of a predetermined time period t_{cl}.

Therefore, in the case of recording a 4T signal in the recording layer 14 of the optical recording medium 10, the number of pulses having a level equal to the recording power *Pw*, namely, the recording pulse number is set to be 3.

Moreover, as shown in Figure 6, in the case of recording one among a 5T signal to a 8T signal in the recording layer 14 of the optical recording medium 10, the power of the laser beam L is modulated so that it is increased from the erasing power *Pe* to the recording power *Pw*, held at the recording power *Pw* during the time period t_{top}, the time periods t_{mp} and the time period t_{lp}, held at the bottom power *Pb* during the time periods t_{off} and the time period t_{cl} and increased from the bottom power *Pb* to the erasing power *Pe* after passage of the time period t_{cl}.

Therefore, in the case of recording one among a 5T signal to an 8T signal in the recording layer 14 of the optical recording medium 10, the number of pulses having a level equal to the recording power *Pw*, namely, the recording pulse number is set to be $(n-1)$ where n is the length of a signal to be recorded.

When the recording layer 14 is irradiated with the laser beam L set to the recording power *Pw*, the phase change material contained in the recording layer 14 is heated to a temperature higher than the melting

point thereof at a region of the recording layer 14 irradiated with the laser beam L, and when it is irradiated with the laser beam L set to the bottom power *Pb*, the melted phase change material is quickly cooled and the phase of the phase change material is changed to the amorphous phase, whereby a record mark is formed and data are recorded in the recording layer 14.

Since the reflective coefficient with respect to a laser beam L of a region of the recording layer 14 where the record mark is formed in this manner and that of a region where no record mark is formed, namely, a blank region, are greatly different, data recorded in the recording layer 14 can be reproduced utilizing the difference in the reflection coefficients between the region of the recording layer 14 where the record mark is formed and the blank region.

The length of the record mark and the length of the blank region between the record mark and the neighboring record mark constitute data recorded in the recording layer 14. The record mark and the blank region are formed so as to have a length equal to an integral multiple of T, where T is a length corresponding to one cycle of a reference clock. In the case where 1,7 RLL modulation code is employed, record marks and blank regions having a length of 2T to 8T are formed.

On the other hand, when a region of the recording layer 14 where a record mark is formed is irradiated with a laser beam L whose power is set to the recording power *Pe*, the region of the recording layer 14 irradiated with the laser beam L is heated to a temperature equal to or higher than the crystallization temperature of the phase change material and when the laser beam L is moved away from the region of the recording layer 14, the region of the recording layer 14 is gradually cooled.

Thus, the phase change material contained is crystallized and the

record mark which was formed at the region of the recording layer 14 is erased.

Therefore, data recorded in the recording layer 14 can be directly overwritten by modulating the power of the laser beam L between the recording power *Pw*, the erasing power *Pe* and the bottom power *Pb*.

In this embodiment, a preferred range of the linear recording velocity to be set when data are recorded in the optical recording medium 10, the pulse train patterns shown in Figures 3 to 6 and a preferred range of the ratio *Pe*/*Pw* of the erasing power *Pe* to the recording power *Pw* of a laser beam L to be used for modulating the power of the laser beam L when data are recorded in the optical recording medium 10 are recorded as data for setting recording conditions in the optical recording medium 10 in the form of wobbles or pre-pits and when data are to be recorded in the optical recording medium 10, the data recording apparatus reads the data for setting recording conditions recorded in the optical recording medium 10 and determines conditions for recording data based on the thus read data for setting recording conditions in accordance with a program for setting recording conditions.

Figure 7 is a diagram showing a data recording apparatus for recording data in the optical recording medium 10.

As shown in Figure 7, a data recording apparatus 100 includes a spindle motor 101 for rotating the optical recording medium 10, an optical head 110 for projecting a laser beam L onto the optical recording medium 10 and receiving the laser beam L' reflected by the optical recording medium 10, a traverse motor 102 for moving the optical head 110 in a radial direction of the optical recording medium 10, a laser drive circuit 103 for feeding a laser drive signal 103a to the optical head 110, a lens drive circuit 104 for feeding a lens drive signal 104a to the optical head

110, and a controller 105 for controlling the spindle motor 101, the traverse motor 102, the laser drive circuit 103 and the lens drive circuit 104.

The optical head 110 includes a laser beam source 111 for emitting the laser beam L based on the laser drive signal 103a, a collimator lens 112 for making the laser beam L emitted from the laser beam source 111 a parallel beam, a beam splitter 113 disposed in the optical path of the laser beam L, an objective lens 105 for condensing the laser beam L, an actuator 106 for moving the objective lens 105 in the vertical direction and the horizontal direction based on the lens drive signal 104a, and a photodetector 116 for receiving the laser beam L' reflected by the optical recording medium 10 and photoelectrically converting it.

The spindle motor 101 is controlled by the controller 105 so as to rotate the optical recording medium 10 at a desired speed of rotation.

The methods for controlling the rotation of the optical recording medium 10 are roughly classified into the CLV method of rotating the optical recording medium 10 while keeping the linear velocity constant and the CAV method of rotating the optical recording medium 10 while keeping the angular velocity constant.

In the case where the rotation of the optical recording medium 10 is controlled using the CLV method, since the data transfer rate can be kept constant irrespective of the position in the radial direction of the optical recording medium 10 where data are being recorded or data are being reproduced, data can be recorded in or data can be reproduced from the optical recording medium 10 at a high transfer rate at all times, so that data can be recorded at high density. On the other hand, however, since the speed of rotation of the optical recording medium 10 has to be changed in accordance with the position in the radial direction of the

optical recording medium 10 where data are being recorded or data are being reproduced, it is necessary to control the spindle motor 101 in a complicated manner and, therefore, the random access speed is low.

To the contrary, in the case where the rotation of the optical recording medium 10 is controlled using the CAV method, since the spindle motor 101 can be controlled in a simple manner, the random access speed is high. On the other hand, however, the CAV method is disadvantageous in that the data recording density at the outer circumference portion of the optical recording medium 10 becomes slightly lower.

The traverse motor 102 is controlled by the controller 105 so as to move the optical head 110 in the radial direction of the optical recording medium 10 and when data are to be recorded in the optical recording medium 10 or data are to be reproduced from the optical recording medium 10, it moves the optical head 110 so that the spot of the laser beam L gradually moves along the groove 11b spirally formed on the optical recording medium 10 from the inner circumference portion to the outer circumference portion of the optical recording medium 10.

In the case of changing the position in the radial direction of the optical recording medium 10 where data are to be recorded or data are to be reproduced, the controller 105 controls the traverse motor 102 to move the spot of the laser beam L to the desired position on the optical recording medium 10.

The laser drive circuit 103 is controlled by the controller 105 so as to feed a laser drive signal 103a to the laser beam source 111 of the optical head 110. The laser beam source 111 generates a laser beam L whose power corresponds to the laser drive signal 103a fed from the laser drive circuit 103.

When data are to be recorded in the optical recording medium 10, the laser drive circuit 103 generates a laser drive signal 103a whose intensity is modulated so that the power of the laser beam L can be modulated in accordance with the above described pulse pattern and feeds it to the laser beam source 111 of the optical head 110. On the other hand, when data are to be reproduced from the optical recording medium 10, the laser drive circuit 103 generates a laser drive signal having a constant intensity and feeds it to the laser beam source 111 of the optical head 110, thereby causing the laser beam source 111 to emit a laser beam L having a reproduction power *Pr* of a constant level.

The lens drive circuit 104 is controlled by the controller 105 so as to feed a lens drive signal to the actuator 115.

The controller 105 is provided with a focus control circuit 105a and when the focus control circuit 105a is turned on, the spot of the laser beam L is focused on the recording layer 14 of the optical recording medium 10 and fixed thereon. The controller is further provided with a tracking control circuit 105b and when the tracking control circuit 105b is turned on, the spot of the laser beam L automatically follows the groove 11b of the optical recording medium 10. Therefore, it is possible for the spot of the laser beam L to be correctly focused on the recording layer 14 of the optical recording medium 10 and to follow the groove 11b of the optical recording medium 10.

In this embodiment, the controller 105 of the data recording apparatus 100 further includes a memory (not shown) and programs for setting recording conditions are stored in the memory.

The thus constituted data recording apparatus 100 records data in the optical recording medium 10 in the following manner.

When the optical recording medium 10 is set in the data recording

apparatus, the controller 105 of the data recording apparatus reads the data for setting recording conditions recorded in the optical recording medium 10 and also reads the program for setting recording conditions stored in the memory.

In this embodiment, in accordance with the composition of the phase change material contained in the recording layer 14 of the optical recording medium 10 and represented by the atomic composition formula: $Sb_aTe_bGe_cMn_d$, a preferred range of a linear recording velocity to be set when data are recorded in the optical recording medium 10, the pulse train patterns shown in Figures 3 to 6 and a preferred range of the ratio *Pe/ Pw* of the erasing power *Pe* to the recording power *Pw* of a laser beam L to be used for modulating the power of the laser beam L when data are recorded in the optical recording medium 10 are determined as data for setting recording conditions and recorded in the optical recording medium 10 in the form of wobbles or pre-pits. Therefore, the controller 105 performs test recording of data on a predetermined track of the optical recording medium 10 based on the thus read data for setting recording conditions in accordance with the program for setting recording conditions read from the memory, thereby determining the recording conditions of data, namely, the linear recording velocity of data, the width of each pulse of the pulse train pattern for modulating the power of a laser beam L and the ratio *Pe/ Pw* of the erasing power *Pe* to the recording power *Pw* of a laser beam L.

The controller 105 then produces a data conditions setting signal based on the thus determined the recording conditions of data and outputs it to the laser drive circuit 103.

The laser drive circuit 103 generates a laser drive signal based on the input data conditions setting signal and outputs it to the laser beam

source 111 of the optical head 110, while it outputs control signals to the spindle motor 101 and the traverse motor 102.

As a result, a laser beam L whose power is modulated by the pulse train pattern determined based on the data conditions setting signal is emitted from the laser beam source 111 and the laser beam L passes through the collimator lens 112 to be made a parallel beam.

The laser beam L then enters the objective lens 114 via the beam splitter 113 and is converged onto the groove 11b formed on the optical recording medium 10.

At this time, the optical recording medium 10 is rotated by the spindle motor 101 at a linear velocity equal to the linear recording velocity determined based on the data conditions setting signal and. therefore, data are recorded in the recording layer 14 of the optical recording medium 10 under desired recording conditions.

To the contrary, when data recorded in the optical recording medium 10 are to be reproduced, the controller 105 causes the laser drive circuit 103 to output a laser drive signal 103a having a predetermined intensity to the laser beam source 111, thereby causing the laser beam source 111 to emit a laser beam L having a reproduction power *Pr* of a predetermined level.

The laser beam L emitted from the laser beam source 111 is projected onto the recording layer 14 of the optical recording medium 10 and reflected by the recording layer 14 of the optical recording medium 10.

The laser beam L' reflected by the recording layer 14 of the optical recording medium 10 is made a parallel beam by the objective lens 114 and reflected by the beam splitter 113.

The laser beam L' reflected by the beam splitter 113 impinges on

the photodetector 116 to be photoelectrically detected thereby and the thus produced data are output to the controller 105.

WORKING EXAMPLES

Hereinafter, a working example will be set out in order to further clarify the advantages of the present invention.

Working Example

An optical recording medium sample # 1 was fabricated in the following manner.

A substrate of polycarbonate having a thickness of 1.1 mm and a diameter of 120 mm and formed with grooves and lands on the surface thereof was first fabricated by an injection molding process.

Then, the substrate was set on a sputtering apparatus and a reflective layer consisting of an alloy containing 90 atomic % or more of Ag and added with Pd and Cu and having a thickness of 100 nm, a second dielectric layer consisting of a mixture of ZnS and SiO_2 and having a thickness of 10 nm, a recording layer containing 58.2 atomic % of Sb, 19.3 atomic % of Te, 5.0 atomic % of Ge and 17.5 atomic % of Mn and having a thickness of 12 nm, a first dielectric layer consisting of the mixture of ZnS and SiO_2 and having a thickness of 25 nm and a heat radiation layer containing 90 atomic % of more of aluminum nitride and having a thickness of 100 nm were sequentially formed on the surface of the substrate on which the grooves and lands were formed, using the sputtering process.

The mole ratio of ZnS to SiO_2 in the mixture of ZnS and SiO_2 contained in the first dielectric layer was 80:20 and the mole ratio of ZnS to SiO_2 in the mixture of ZnS and SiO_2 contained in the second dielectric

layer was 50:50.

Further, the support substrate formed with the reflective layer, the second dielectric layer, the recording layer, the first recording layer and the heat radiation layer on the surface there of was set on a spin coating apparatus and the heat radiation layer was coated with a resin solution prepared by dissolving acrylic ultraviolet curing resin in a solvent to form a coating layer and the coating layer was irradiated with ultraviolet rays, thereby curing the acrylic ultraviolet curing resin to form a protective layer having a thickness of 100 μm.

Thus, the optical recording medium sample # 1 was fabricated.

Further, an optical recording medium sample #2 was fabricated in the manner of the optical recording medium sample # 1 except that a recording layer containing 57.4 atomic % of Sb, 19.1 atomic % of Te, 6.1 atomic % of Ge and 17.7 atomic % of Mn was formed.

Then, an optical recording medium sample #3 was fabricated in the manner of the optical recording medium sample # 1 except that a recording layer containing 56.1 atomic % of Sn, 18.8 atomic % of Te, 8.6 atomic % of Ge and 16.5 atomic % of Mn

Further, an optical recording medium comparative sample #1 was fabricated in the manner of the optical recording medium sample # 1 except that a recording layer containing 75.2 atomic % of Sn, 18.1 atomic % of Te, 4.7 atomic % of Ge and 2.0 atomic % of Mn was formed.

Then, an optical recording medium comparative sample #2 was fabricated in the manner of the optical recording medium sample # 1 except that a recording layer containing 56.2 atomic % of Sn, 18.7 atomic % of Te, 5.3 atomic % of Ge and 19.8 atomic % of Mn was formed.

Further, an optical recording medium comparative sample #3 was fabricated in the manner of the optical recording medium sample # 1

except that a recording layer containing 59.8 atomic % of Sn, 19.9 atomic % of Te, 3.7 atomic % of Ge and 16.6 atomic % of Mn was formed.

Moreover, each of the optical recording medium samples #1 to #3 and the optical recording medium comparative samples #1 to #3 was set in an optical recording medium evaluation apparatus "DDU1000" (Product Name) manufactured by Pulstec Industrial Co., Ltd. and a laser beam having a wavelength λ of 405 nm was focused onto each of the recording layers using an objective lens whose numerical aperture was 0.85 via the light transmission layer while each sample was rotated at a linear velocity of 10.5 m/sec, thereby recording random signals including 2T signals to 8T signals in the 1,7 RLL Modulation Code therein.

The power of the laser beam was modulated in accordance with the pulse train patterns shown in Figures 3 to 6 wherein the recording power *Pw*, the erasing power *Pe* and the bottom power *Pb* of the laser beam were set as shown in Table 1.

Table 1

	Power of Laser beam (mW)			
	Pw	Pe	Pb	Pe/Pw
Sample #1	6.0	3.0	0.5	0.50
Sample #2	5.6	2.8	0.5	0.50
Sample #3	5.6	3.0	0.5	0.54
Comparative Sample #1	4.6	2.0	0.5	0.43
Comparative Sample #2	6.0	3.0	0.5	0.50
Comparative Sample #3	6.2	3.0	0.5	0.48

Then, each of the optical recording medium samples #1 to #3 and the optical recording medium comparative samples #1 to #3 was set in the above mentioned optical recording medium evaluation apparatus and a laser beam having a wavelength λ of 405 nm was focused onto each of the recording layers using an objective lens whose numerical aperture was 0.85 via the light transmission layer while each sample was rotated at a linear velocity of 10.5 m/sec, thereby reproducing a signal recorded in the recording layer and jitter *J0* of the reproduced was measured.

The reproducing power of the laser beam was set to 0.44 mW.

As a result, the signal recorded in each of the optical recording medium samples #1 to #3 and the optical recording medium comparative samples #1 and #3 could be reproduced but the signal recorded in the optical recording medium comparative sample #2 could not be reproduced because the amount of the laser beam reflected by the optical recording medium comparative sample #2 was too small.

Then, the signal recorded in each of the optical recording medium samples #1 to #3 and the optical recording medium comparative samples #1 and #3 was repeatedly reproduced with the reproducing power of the laser beam set to 0.8 mW and jitter of the reproduced signal was measured, thereby obtaining the number *N1* of the signal reproducing operations that degraded jitter by 1 % from the jitter *J0*.

Further, the signal recorded in each of the optical recording medium samples #1 to #3 and the optical recording medium comparative samples #1 and #3 was repeatedly reproduced by setting the reproducing power of the laser beam to 0.7 mW and jitter of the reproduced signal was measured, thereby obtaining the number *N2* of the signal reproducing operations that degraded jitter reduced by 1 % from the jitter *J0*.

The results of the measurements are shown in Table 2.

Table 2

	Number of Signal reproducing operations	
	N1	N2
Sample #1	12	400
Sample #2	46	1,600
Sample #3	400	20,000
Comparative Sample #1	90	250
Comparative Sample #3	14	220

Further, the results of the measurements shown in Table 2 were used to calculate the reproducing power that would degrade jitter of a signal obtained by reproducing the signal recorded in each of the optical recording medium samples #1 to #3 and the optical recording medium comparative samples #1 and #3 by 1 % from the jitter J0 over one million reproductions.

The results of the calculation are shown in Table 3.

Table 3

	Reproducing Power
Sample #1	0.48
Sample #2	0.52
Sample #3	0.60
Comparative Sample #1	0.36
Comparative Sample #3	0.39

As shown in Table 3, it was found that the reproducing power at which jitter of a signal obtained by reproducing the signal recorded in

each of the optical recording medium samples #1 to #3 would be degraded by 1 % from the jitter J0 over one million reproductions was equal to or higher than 0.48 mW, while the reproducing power at which jitter of a signal obtained by reproducing the signal recorded in each of the optical recording medium comparative samples #1 and #3 would be degraded by 1 % from the jitter J0 over one million reproductions was lower than 0.40 mW and that each of the optical recording medium samples #1 to #3 had high data reproduction durability.

The present invention has thus been shown and described with reference to specific embodiments and the Working Example. However, it should be noted that the present invention is in no way limited to the details of the described arrangements but changes and modifications may be made without departing from the scope of the appended claims.

For example, in the above described embodiment, the optical recording medium 10 includes the reflective layer 12, the second dielectric layer 13, the recording layer 14, the first dielectric layer 15, the heat radiation layer 16 and the light transmission layer 17 on the support substrate 11 in this order. However, in order to prevent the reflective layer 12 from being corroded, it is possible to form between the support substrate 11 and the reflective layer 12 a moisture-proof layer of oxide, sulfide, nitride or carbide of Al, Si, Ce, Ti, Zn, Ta or the like such as Al_2O_3, AlN, ZnO, ZnS, GeN, GeCrN, CeO_2, SiO, SiO_2, Si_3N_4, SiC, La_2O_3, TaO, TiO_2, SiAlON (mixture of SiO_2, Al_2O_3, Si_3N_4 and AlN), LaSiON (mixture of La_2O_3, SiO_2 and Si_3N_4) or the like. In the case where the moisture-proof layer is provided between the support substrate 11 and the reflective layer 12, it is preferable to form the moisture-proof layer of the mixture of ZnS and SiO_2.

Further, in the above described embodiment, although the optical

recording medium 10 includes the reflective layer 12, the second dielectric layer 13, the recording layer 14, the first dielectric layer 15, the heat radiation layer 16 and the light transmission layer 17 on the support substrate 11 in this order, an interface layer may be formed between the recording layer 14 and the first dielectric layer 15 of the mixture of ZnS and SiO_2 whose mole ratio is 40:60 to 60:40, particularly, 50:50.

Furthermore, in the above described embodiment, although the optical recording medium 10 includes the reflective layer 12, the second dielectric layer 13, the recording layer 14, the first dielectric layer 15, the heat radiation layer 16 and the light transmission layer 17 on the support substrate 11 in this order, a hard coat layer may be formed on the surface of the light transmission layer 17 to protect the light transmission layer 17.

Moreover, in the above described embodiment, a preferred range of a linear recording velocity to be set when data are recorded in the optical recording medium 10, the pulse train pattern shown in Figures 3 to 6 and a preferred range of the ratio Pe/Pw of the erasing power Pe to the recording power Pw of a laser beam L to be used for modulating the power of the laser beam L when data are recorded in the optical recording medium 10 are recorded as data for setting recording conditions in the optical recording medium 10 in the form of wobbles or pre-pits and when data are to be recorded in the optical recording medium 10, the data recording apparatus reads the data for setting recording conditions recorded in the optical recording medium 10 and determines conditions for recording data based on the thus read data for setting recording conditions in accordance with a program for setting recording conditions. However, it is not absolutely necessary for the optical recording medium 10 to store, as data for setting recording conditions, all of the preferred

range of a linear recording velocity to be set when data are recorded in the optical recording medium 10, the pulse train patterns shown in Figures 3 to 6 and a preferred range of the ratio *Pe*/ *Pw* of the erasing power *Pe* to the recording power *Pw* of a laser beam L to be used for modulating the power of the laser beam L when data are recorded in the optical recording medium 10 but the optical recording medium 10 may store only a part or parts thereof. Further, it is possible to write ID data for identifying the optical recording medium 10 in the optical recording medium, store all, or a part or parts of the data for setting recording conditions in the memory of the data recording apparatus and cause the data recording apparatus to read the data for setting recording conditions from the memory in accordance with the ID data and set the recording conditions of data.

According to the present invention, it is possible to provide a data rewritable type optical recording medium whose characteristics of recording data therein at a high linear velocity can be improved and whose data reproduction durability and storage reliability can be simultaneously improved.